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(54) Sonic-actinic cleaning and sterilising of instruments

(57) A source of actinic radiation, e.g. a UV lamp 4, is positioned to irradiate cleaning liquid 8 in a metal tank 1 (e.g. being mounted inside a tank lid 2 which is shaped as a reflector). There may be a thermostatted heater 13 for the tank. A piezoelectric transducer 10, 11, 12 agitates the liquid 8 ultrasonically. The liquid may be circulated through loop 14 by pump 17, causing macroscopic agitation and allowing liquid and/or entrained waste to be discharged through tap 18. Ambient air may be blown through an aperture 5 in the lid 2, sterilised by radiation, and serve to dry the cleaned articles 9 after discharge of the liquid 8.

Operation of pump 17, heater 13, lamp 4 etc may be controlled by an automatic programmer 26.

The micro- and macroscopic agitation causes contaminants such as bacteria to be dislodged from all parts of the articles, dispersed in the bulk of the liquid, and neutralised by irradiation before agitation ceases.

FIG_1

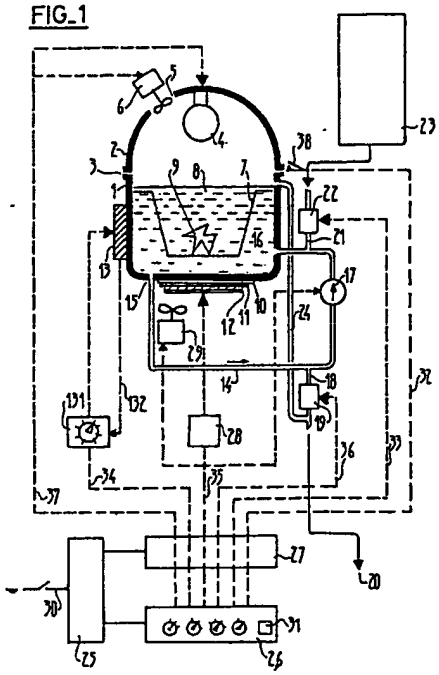

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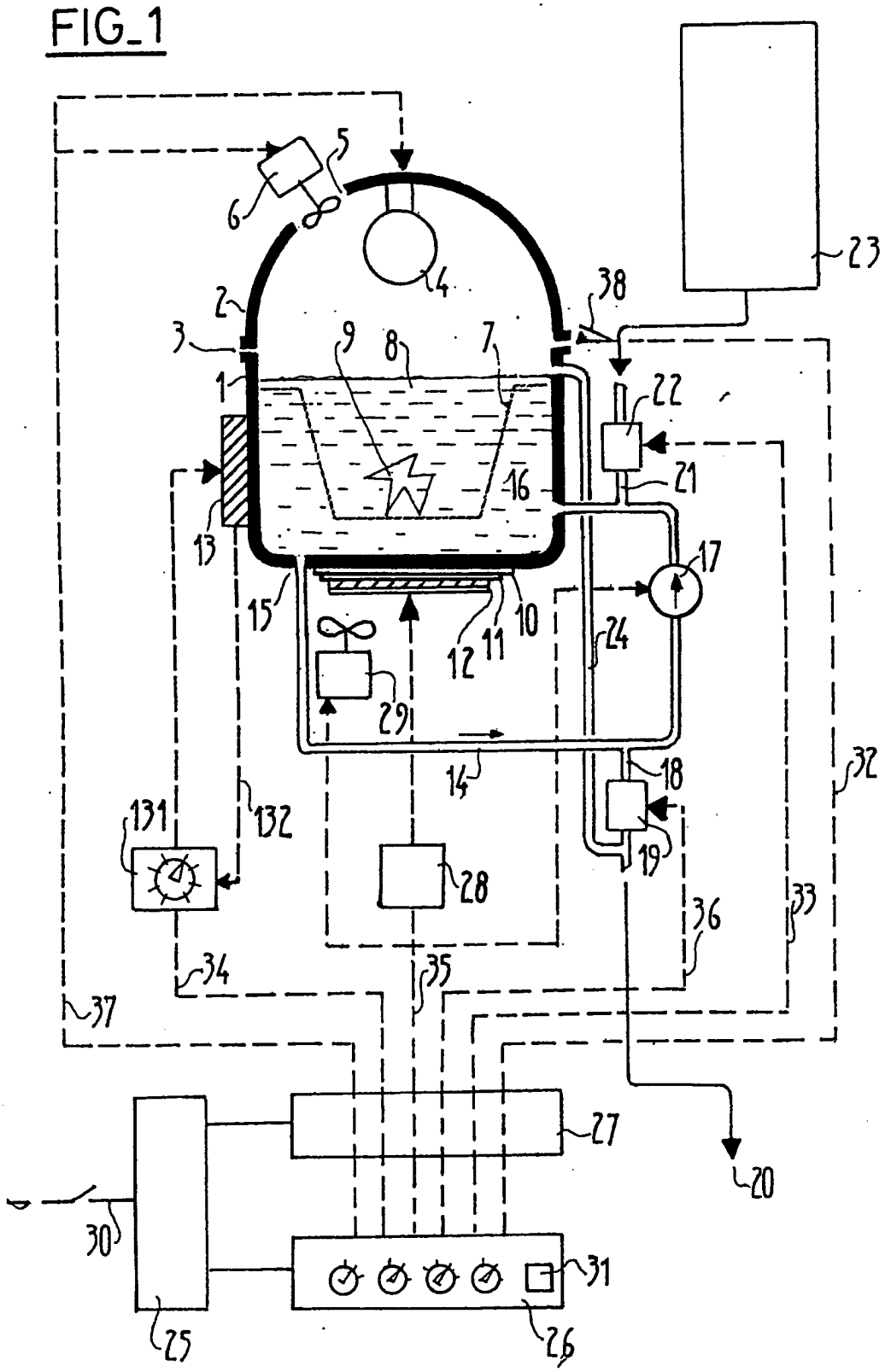
FIG_1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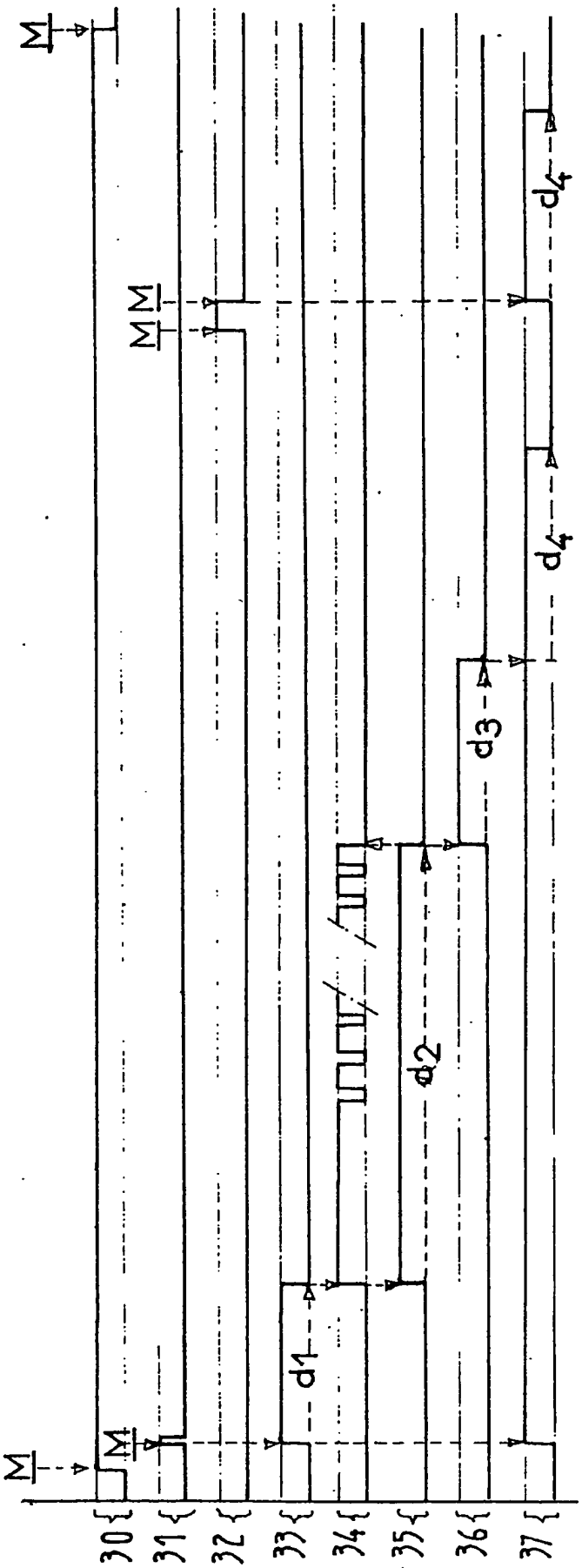

FIG.2

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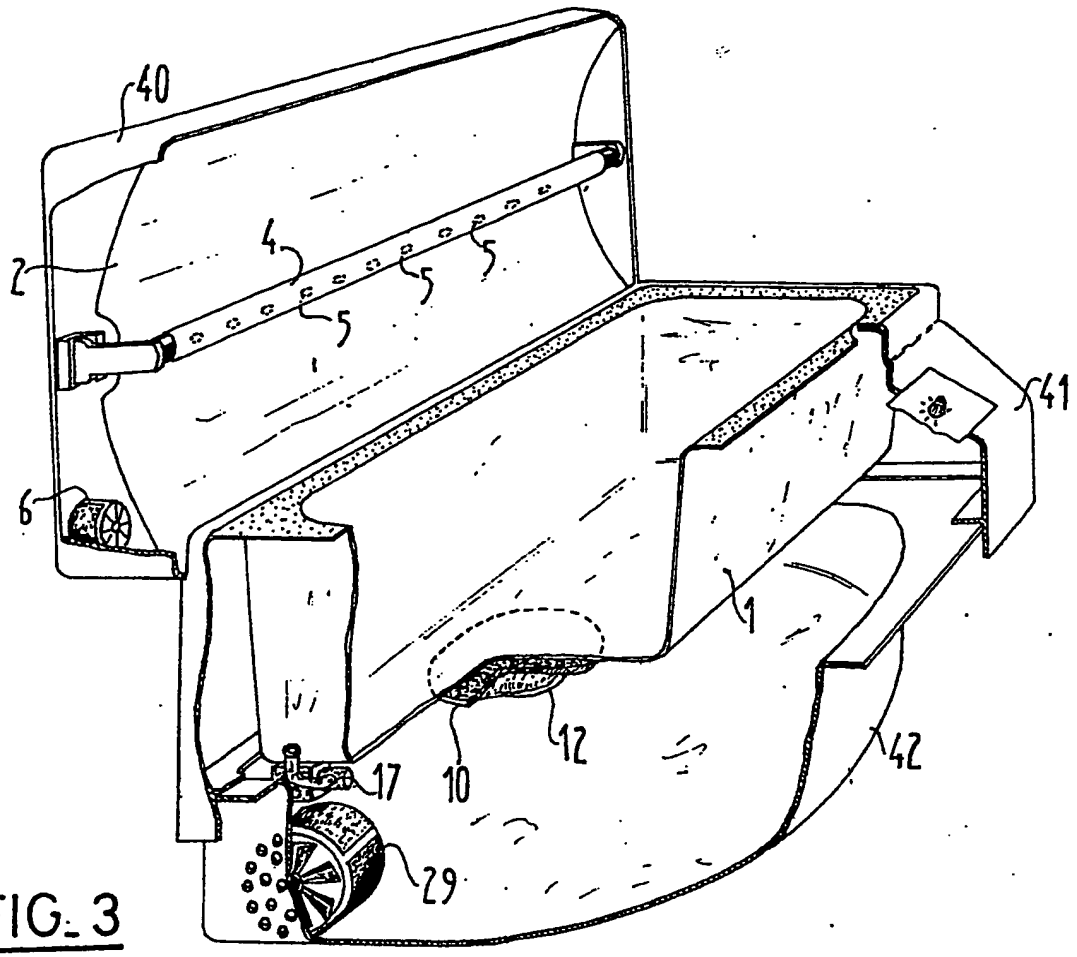

FIG_3

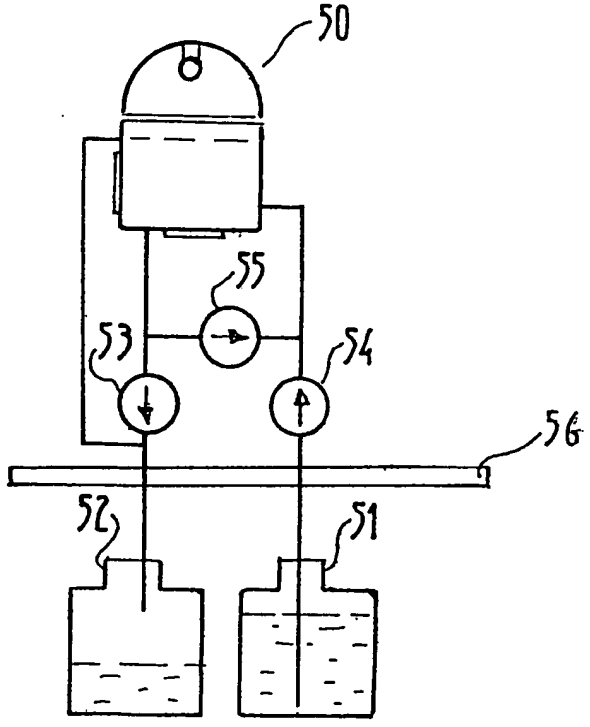

FIG_4

SPECIFICATION

Sonic-actinic cleaning and sterilising of instruments

The present invention relates generally to the cleaning of small articles, such as surgical, dental, and laboratory instruments, culinary implements and mechanical, watch and jewellerry parts which require careful cleaning and sometimes even sterilization before being put to use.

Cleaning devices have heretofore been known which employ ultrasonic vibrations to effect a cleaning operation. In general, these devices make use of a tank having an ultrasonic generator secured to the exterior of the tank bottom or to a wall thereof, the ultrasonic generator being of the piezoelectric quartz or magnetostriction type. The articles to be cleaned are placed in the tank where they are submerged in a liquid which, depending on the cleaning procedure, may be water having a detergent therein or, in some instances, an organic solvent.

It is known that ultrasonic vibrations within the liquid give rise to zones of compression and rarefaction which act mechanically on a microscopic scale but in a violent manner on the articles immersed in the liquid. This phenomenon is referred to as cavitation. The foreign substances present on the surface of the articles to be cleaned are thereby dislodged therefrom and dispersed within the liquid.

When the articles to be cleaned are implements for medical or scientific use, the tools cleaned in this manner are thereafter often subjected to a sterilization procedure. Sterilization is effected by passing the tools through an oven or an autoclave, or by immersion in a sterilizing liquid. In some instances, sterilization is effected by exposure within a chamber to actinic radiation, such as ultraviolet rays.

A sterilization procedure subsequent to ultrasonic cleaning, unless it is effected by autoclaving, may not always be effective. Thus if the articles to be cleaned have cavities therein, the dirt particles dispersed in the liquid as a result of ultrasonic activity will deposit in these cavities where they will be shielded from the bactericidal effect of ultraviolet irradiation or from the chemical agent used for sterilization.

Another drawback encountered in known ultrasonic cleaning and sterilization procedures resides in the need for successive handling of the articles in order to subject them to both cleaning and sterilization.

By means of the present invention it may be possible to provide a method and apparatus which make it possible to have clean and sterilized implements after they have been treated for a predetermined time period, whereby the operations carried out by the user are limited to placing the implements in a tank containing a cleaning liquid, initiating a cleaning and sterilization program, and removing them when the implements are needed after the program has been completed.

More particularly, an object of the invention is to provide an apparatus which causes ultrasonic agitation within the liquid in which the articles to be cleaned are immersed and which at the same time irradiates the liquid by means of actinic light, such as ultraviolet rays.

A preferred feature of an apparatus in accordance with the invention is that dirt particles contaminated by bacteria are dislodged from the surfaces of articles to be cleaned and from the cavities therein, and are dispersed in the liquid wherein the contaminants are exposed to actinic radiation and thereby destroyed.

Another preferred feature of an apparatus in accordance with the invention is that the articles to be cleaned are kept at all times exposed to the actinic radiation after the withdrawal of the liquid from the tank and until they are used.

It is to be understood that simultaneous ultrasonic cleaning and ultraviolet radiation in accordance with the invention is not equivalent to successive ultrasonic cleaning and sterilization by radiation. In fact, microscopic agitation of the liquid is preferably succeeded at the end of a certain period of time by a macroscopic agitation which has the effect of bringing the bacteria removed by microscopic agitation into the field of ultraviolet irradiation. In its result, therefore, the action of ultraviolet rays could be equivalent to agitation of a liquid which in itself has a bactericidal effect. Moreover, it is also known that bactericidal chemical agents such as chlorine or chlorinated products may have a deleterious effect on the surfaces of small medical or scientific implements.

In a preferred form, the present invention provides an apparatus of the above-described type in which the source of actinic radiation is located below a cover which forms a reflector and is arranged on top of the tank.

Another preferred feature of the invention resides in the fact that the apparatus includes means to heat the liquid, which heating means may advantageously take the form of a resistor bonded to the tank by a silicone elastomer.

In accordance with another aspect of the invention, an apparatus may include means for filling the tank with liquid and which, when the tank is full, brings about a macroscopic circulation of the liquid therein.

In accordance with yet another aspect of the invention, the apparatus may further include means for introducing ambient air below the cover of the tank in the vicinity of the actinic radiation source, the air introduced serving to dry the cleaned articles and being itself subjected to the sterilizing action of the radiation.

A preferred embodiment of apparatus in accordance with the invention includes a programmer acting to automatically control a sequence of operations which take place after the apparatus is turned on and the cover is closed. When the cycle is manually initiated, the following steps may be carried out by the programmer:

A Activation of the liquid-filling means, the heating means, the radiation source, the ambient-air blower and the cooling blower;

B After a predetermined period of time *d1*, inhibition of the liquid-filling means and simultaneous activation of the ultrasonic generator;

C After a predetermined period of time *d2*, inhibition of the ultrasonic generator and activation of the liquid-emptying means;

D After a predetermined period of time *d3*, inhibition of the liquid-emptying means and inhibition of the cooling blower;

E After a predetermined period of time *d4*, inhibition of the radiation source and the ambient-air blower, the apparatus then again being in its initial state.

The radiation source and the ambient-air blower may advantageously be reactivated for a new time period *d4* by the closing of the tank cover and be inhibited by the opening thereof. This arrangement affords protection against the risk of electrocution inherent in the relatively high operating voltage for the radiation source when this source is activated, yet makes certain that a period of air sterilization follows an introduction of non-sterile ambient air when the cover is opened.

For a better understanding of the invention as well as other objects and further features of preferred embodiments thereof, reference is made to the following detailed description to be read in conjunction with the accompanying drawings, wherein:

Fig. 1 is a schematic diagram of an apparatus in accordance with the invention;

Fig. 2 is a function/time diagram;

Fig. 3 is a fragmentary isometric showing of a preferred tank and housing assembly; and

Fig. 4 schematically illustrates a modified arrangement for filling and emptying the tank.

The System:

Referring to Fig. 1, an apparatus in accordance with the invention includes a metal tank 1 having a cover 2 hinged on edge 3 of the tank. Cover 2 forms a reflector, the curvature of which may be cylindrical, parabolic or of any other shape which permits the concentration of radiation into the underlying tank. Below cover 2 there is disposed an ultraviolet ray lamp 4 constituting the source of actinic light. Adjacent lamp 4, an opening 5 formed in reflector 2 makes it possible by means of a blower 6 to introduce a stream of ambient air towards the lamp, which air is supplied into the space between tank 1 and cover 2.

A basket 7 is suspended within the liquid 8 contained in tank 1. This liquid may be ordinary water, distilled water or demineralized water. Articles to be cleaned such as those symbolically indicated by numeral 9, are placed in basket 7.

On the exterior surface of the tank bottom there is attached an ultrasonic generator. This is composed of an aluminium plate 10 bonded to the bottom surface, the plate acting to protect the piezoelectric crystal and to accommodate its frequency to the resonance frequency of the tank, a washer 11 of Celoron bonded to plate 10 and providing thermal insulation, and a transducer 12 bonded to washer 11 and formed of a piezoelectric crystal and its electrodes. A suitable adhesive for these bondings may be a cyano-acrylic glue.

Bonded to the exterior surface of one wall of the tank by means of a silicone elastomer is a heater resistor 13 which serves to heat the liquid through the wall of the tank. Resistor 13 is controlled by a regulator 131 which obtains its start-stop information 132 from a sensor located on the tank in the vicinity of resistor 13.

The filling, circulating and emptying means for the liquid includes a loop 14, one end of which communicates with a low point 15 in the tank to permit the discharge of liquid therefrom, the other end of which communicates with a point 16 located on a side wall in the vicinity of the bottom. Interposed in loop 14 is a pump 17 which is primarily intended to circulate the liquid in the tank. Pump 17 is of the "positive" type; that is to say, when stopped it does not permit flow of the liquid. Upstream of pump 17 in loop 14 is a first tap 18, which, via a first solenoid valve 19, leads to a sewer or sump 20. Tap 18 is advantageously located vertically below the loop 14 so as to permit entrapment of the dense dirt entrained in the loop by gravity flow.

In accordance with a modification not shown in the drawing, tap 18 is shaped as a cyclone so as to accentuate the phenomenon of gravity entrapment. Downstream of pump 17 is a second tap 21 which leads, via a second solenoid valve 22, to a liquid supply 23. An overflow conduit 24, one end of which is coupled to the tank in the vicinity of the upper edge thereof, is connected to the sump pipe downstream of solenoid valve 19.

The apparatus also includes an oscillator 28 whose function is to generate electrical oscillations having a frequency adapted to drive transducer 12 to produce ultrasonic vibrations. It furthermore includes a blower 29 acting to cool the power components, such as transducer 12 and oscillator 28, by pulsating air brought in from the outside. The system also includes a sensor, such as a microswitch 38, to detect whether cover 2 is open or closed, the switch being activated when the cover is opened.

Automatic operation of the apparatus is carried out by a programmer 26 which is preferably of the integrated logic circuit type operating in accordance with the sequential mode from a time base which may be either a crystal oscillator or any other constant frequency source such as the frequency of a commercial power line. The programmer may also be of the electromechanical type; but in that event, it will have less flexibility in its adjustment capabilities.

Programmer 26 acts on the operating components of the system such as the pump motor, the resistor, the oscillator, etc., via a power stage 27 formed, for instance, of electromagnetic micro-relays. Programmer 26 and power stage 27 obtain the power necessary for their operation from a power supply box 25 which, in turn, is connected to the power line by means of a main switch 30.

The dashed lines shown in Fig. 1 represents the electrical control or power connections between the programmer, the power stage and the various operating components of the system. The voltage

condition of these lines is of the binary type; that is, it is either activated (under voltage) or inhibited (without voltage).

Operation:

The respective conditions of the lines in the system illustrated in Fig. 1 in the course of an operating cycle are shown in Fig. 2. In this diagram, a manual action or an action independent of the operating cycle is represented by an arrowhead on a dashed line over which there is the letter M.

The course of an operating cycle will now be explained by reference to Figs. 1 and 2. Tank 1 is assumed to contain articles to be cleaned and cover 2 is closed. The first step involves placing the system under voltage by means of switch 30 and then initiating the operating cycle by depressing a push button 31 on programmer 36. This activates lines 33 and 37. As a consequence, solenoid valve 22 on line 33 is opened to permit the flow of liquid from supply 23 into tank 1. At the same time, lamp 4 is turned on and blower 6 placed in operation, the lamp and blower both being on line 37.

Activation of lines 33 and 37 initiates the time count of a predetermined time period *d1* in the programmer, this period corresponding to the estimated time for filling tank 1 with liquid. At the conclusion of time period *d1*, line 33 is returned to its inhibited condition, closing off solenoid valve 22, whereas lines 34 and 35 are caused to change to their activated condition. Activation of line 34 has the effect of supplying power to resistor 13 to commence heating of the liquid. Activation of line 35 has the effect of placing pump 17, oscillator 28 and blower 29 simultaneously in the operation. Activation of line 35 also has the effect of initiating the time count of a second predetermined time period *d2*. The conclusion of this second time period simultaneously causes the return of lines 34 and 35, to their inhibited condition and places line 36 in its activated condition.

The predetermined time period *d2* is the time estimated to be necessary to carry out cleaning and sterilization of the articles by the combined action of ultrasonic agitation and ultraviolet irradiation. Placing line 36 in its activated condition initiates the time count of a third predetermined time period *d3*, the conclusion of which brings about the return of line 36 to its inhibited condition. Activation of line 36 results in the opening of solenoid valve 19, the time period *d3* being that estimated as necessary to effect emptying of tank 1.

Placing line 36 in its inhibited condition also has the effect of initiating the time count of a predetermined fourth time period *d4*, the conclusion of which causes the return of line 37 to its inhibited condition, thereby terminating emission from lamp 4 and cutting off air blower 6. At the conclusion of this final period, the articles in the tank are dry and sterilized if they have been suitably arranged therein and are enveloped by air which is itself sterilized. By maintaining lamp 4 in operation after the tank is emptied of liquid for time period *d4*, the air which supplants the liquid in the tank is caused to undergo sterilization by the ultraviolet rays.

Provision is made that when cover 2 is raised in order, for example, to permit the removal of an article such as a surgical instrument from the tank, line 32 is then activated. Closing of the cover returns line 32 to its inhibited condition. This cover-opening action again places line 37 in its activated condition for a new time period *d4* to operate lamp 4 and blower 6. Tank 1 will be refilled in a new operating cycle only after push-button 31 has again been depressed.

Fig. 3 shows an apparatus in accordance with the invention in a preferred embodiment thereof, the representation being incomplete with respect to the operating components and being fragmentary with respect to the tank and the housing therefor. The elements of Fig. 3 which are also included in the schematic diagram of Fig. 1 have the same reference numerals applied thereto. Thus reflector 2 is fitted into a cover housing 40. Reflector 2 is provided with a plurality of openings 5 located in the vicinity of lamp 4, preferably just above it. Blower 6 is disposed in the space between cover housing 40 and reflector 2, the blower acting to draw from the exterior and forcing it through the openings.

Bonded to the outer surface of the bottom of tank 1 is aluminium washer 10 to which transducer 12 is bonded. Tank 1 is supported within a housing 41 which in turn is supported by a base 42. In the space defined between tank 1, housing 41 and base 42, are located the various operating and control components, such as cooling blower 29 and pump 17. Base 42, cover housing 40 and tank housing 41 may be made of a suitable polyester resin reinforced with glass fibers.

In another embodiment of the invention which is not shown in the figures, the cover and its cover housing are supported in the manner of a cross arm by a tubular mast placed in one of the side edges of the tank housing. The mast may simultaneously slide vertically in its housing and turn around its axis. The vertical movement of the mast can advantageously be assisted by a counterweight or spring. In this embodiment, the control members and the power stage are housed in the cover housing, the mast also serving as sheathing both for the power lines and for the flow of the air from the tank housing to the cover housing and then to the vicinity of the lamp.

In Fig. 4, an apparatus 50 in accordance with any of the embodiments of the invention disclosed hereinabove is provided with a special liquid circuit specifically intended to assure filling of the tank from a reservoir 51 located below a drainboard 56 and to assure emptying thereof into another reservoir 52 also located below drainboard 56. An arrangement in this form is useful in those cases where the cleaning liquid is a costly liquid such as alcohol or an organic solvent, and one wishes to recover the liquid for recycling after treatment.

In accordance with this arrangement, the solenoid valves of Fig. 1 are replaced by positive pumps 53 and 54, respectively. Pump 55, located in the tank loop, has the same position and plays the same role as pump 17 of Fig. 1. Of course, in this arrangement, pumps 53, 54 and 55 cannot be simultaneously activated any more so than the pump and the solenoid valves of Fig. 1. It must also be understood that the

suction and delivery heads of pump 54 must be sufficient to assure raising of liquid from reservoir 51 into the tank.

While there has been shown and described preferred embodiments of sonic-actinic apparatus for cleaning and sterilizing instruments in accordance with the invention, it will be appreciated that many changes and modifications may be made therein without, however, departing from the essential spirit thereof.

CLAIMS

1. A method for cleaning and sterilizing articles such as surgical instruments, culinary implements and the like, said method comprising the steps of:

A placing the articles in a tank containing a cleaning liquid;

B subjecting the liquid in the tank to ultrasonic agitation to dislodge contaminated dirt particles from the articles and to disperse the particles in the liquid; and

C simultaneously irradiating the liquid with actinic rays to destroy the contaminants therein, whereby the articles are both cleaned and sterilized.

2. Apparatus for cleaning and sterilizing articles such as surgical instruments, culinary, implements and the like comprising:

A a tank for containing a cleaning liquid;

B means to support said articles in said tank;

C an ultrasonic generator secured to the exterior surface of a wall of the tank to subject the liquid therein to ultrasonic agitation;

D an actinic radiation source for irradiating the liquid in the tank; and

E means to simultaneously energize said generator and said source, whereby contaminated dirt dislodged from the articles by said ultrasonic agitation and dispersed in said liquid is subjected to radiation to destroy the contaminants.

3. Apparatus as set forth in claim 2, further including means to heat the liquid.

4. Apparatus as set forth in claim 3, wherein said heating means is constituted by a resistor bonded to the exterior surface of a wall of the tank bya silicone elastomer.

5. Apparatus as set forth in claim 2, further including means to fill said tank with said liquid and when said tank is full for circulating the liquid therein, and means for emptying the liquid from the tank.

6. Apparatus as set forth in claim 2, wherein said tank is provided with a removable cover within which is mounted said radiation source, further including means to introduce ambient air through the cover in the vicinity of the source whereby the air is also subjected to the sterilizing action of the radiation.

7. Apparatus as set forth in claim 2, wherein said radiation source is constituted by an ultraviolet ray lamp.

8. Apparatus as set forth in claim 2, wherein said ultrasonic generator is constituted by an aluminum plate bonded to the bottom wall of the tank, a thermal insulation washer bonded to the plate, and a piezoelectric crystal bonded to the washer.

9. Apparatus for cleaning and sterilizing articles such as surgical instruments, said apparatus comprising:

A a tank having a removable cover for containing a cleaning liquid and having means therein for supporting said articles in said liquid;

B a heater attached to the outer surface of a wall of the tank;

C an ultrasonic transducer attached to the outer surface of a wall of the tank;

D an air blower to introduce ambient air through the corner into the tank;

E an ultraviolet lamp disposed within the cover;

F a cooling blower to cool said generator;

G means for filling said tank with said liquid;

H means for emptying said tank of liquid; and

I a programmer operatively coupled to the above-identified components B to H which are initially inhibited to successively carry out the following operations in the course of an operating cycle:

(1) activating the filling means, the heater, the lamp, the air blower and the cooling blower;

(2) after a first predetermined time period inhibiting the filling means and simultaneously activating the generator;

(3) after a second predetermined time period inhibiting the generator and activating the emptying means;

(4) after a third predetermined period of time inhibiting the emptying means and inhibiting the cooling blower; and

(5) after a fourth predetermined period of time inhibiting the lamp and inhibiting the air blower, the apparatus then being returned to its initial condition.

10. Apparatus for cleaning and sterilising articles substantially as described herein with reference to figs. 1 to 3 or to fig. 4 of the accompanying drawings.

11. Method for cleaning and sterilising articles substantially as described herein with reference to figs. 1 to 3 or to fig. 4 of the accompanying drawings.

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